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CONNECTION DEVICE FOR A DISPLAY SCREEN AND DISPLAY SCREEN COMPRISING SUCH A DEVICE

The invention relates to a connection device for a display screen.

The invention is more particularly applicable to liquid-crystal display devices with a matrix access screen. Such screens comprise conducting tracks placed horizontally, called rows, and conducting tracks placed vertically, called columns. The number of points of intersection between the rows and the columns determines the maximum resolution of the image that can be obtained. The constant increase in this resolution leads to increasing the number of rows and columns even more for the same screen area. In order to set an order of magnitude, the conducting tracks may have a width of 250 μm and be separated by a distance of the same order, their thickness being less than 1 μm . These conducting tracks are connected to their control circuits by means of a bundle of conducting wires placed in a web.

The known solutions for connecting networks of parallel conducting tracks on

an insulating support are:

- The use of conventional connectors:

Connectors requiring glass-piercing operations cannot be used. The glass plates must therefore necessarily be inserted into a connector for printed circuits (a gripping type and a rubbing contact type). None of these connectors has a pitch less than 1.27 mm, which leads to the development of networks etched on glass. This development will adversely affect the technology of the heating network either, if remaining with a thin layer, by altering the resistances to be taken into account, or if changing to a thick layer, by a range of complex additional operations. The dimensional increase of the glass plates caused by the development also leads to problems of mechanical strength. Furthermore, the thin layers used to produce the networks do not have sufficient mechanical abrasion resistance (thickness of 3000 Å) to avoid the thickening operation.

- Ultrasound microwelding:

This technique only provides electrical continuity and has the main drawbacks of:

- the need to thicken the welding zones on the network when there is compatibility between metal of the network and wire (thickening from 300 Å to 1 µm) or producing a multilayer in order to provide this compatibility;

- manual microwelding is lengthy and visually very painful for the operator, automation does not eliminate the mechanical fragility;

- the need to provide redundancy of contacts by means of a second wire,

which leads to 2 wires and 4 welds per connected track.

- Microwelding by meltable alloy:

In this technique, conventional alloys which are dominated by the tin-lead eutectic (SnPb 63-37) are used.

- It may be a wire to wire technique which has difficulties of the same order as for the ultrasound microwelding.

- It may also be a block welding technique: a graded wire, placed perpendicularly and between the two networks to be connected, are then completely melted. During the liquid phase, the capillary action causes the alloy to move along the tracks of the networks, the liquid phase must "wet" the materials of the tracks and not "wet" the substrate bearing the tracks. If the volume of meltable alloy is not too high, the phenomena of capillary action and of wettability fully act to cause the break in continuity of the weld "bead" between contiguous tracks on the substrates. Apart from the difficulties of producing this type of wire, there are other problems associated with the necessary hardware, in particular the thermal problems caused by the large size of the heating bit (greater than 100 mm in order to avoid successive "passes").

- Finally, it may be a remelting technique. However there are no preforms at the sizes and pitches of the contact points. Furthermore, since the liquid crystal screen is filled before welding, in this technology, there would be a very high risk of destruction caused by the differential expansion between liquid and envelope (temperature effect).

- Connection by means of elastomers:

Currently, there are three types of elastomers on the market.

- Filled elastomers consist of a stack of elastomer slices, which conduct by means of a graphite or silver filler, and of insulating elastomer slices. These "connectors" have spurious contact resistances which are systematically greater than $1000\ \Omega$ and require considerable crushing (10 to 15%) which results in applying crushing forces of at least several kilograms (2 to 6 kg for 10 cm for the majority of these connectors).

- Embedded wire elastomers comprise wires which provide the connection by means of their ends. Apart from the difficulties due to the pitch of the wires, which is not compatible with the actual networks, a problematic change in the perturbing resistance during tests on the heating networks can be noted. The contact resistance is close to one ohm if the force crushing the elastomer is sufficient. The risk of scratching and of "cutting" the tracks is not insignificant. In this case also, the crushing force is high. The irregularity of its application over the length of the connector causes many contact deficiencies.

- The elastomers with surface wires are generally U-shaped, which makes it possible to decrease the crushing forces between the two arms. The use of gold-plated wires however requires a considerable force in order to attempt to obtain spurious resistances which are stable and less than about 10 ohms.

To alleviate the drawbacks of the prior art which have just been summarized, the present invention comprises conducting microballs and insulating microballs in suspension in a polymerizable resin, and this makes it possible to provide:

- a spurious electrical resistance between the networks to be connected of less than one ohm;

- a very high insulating electrical resistance between contiguous tracks of the same network;
- good sealing of the contact points;
- considerable connection redundancy (several tens of contact points between the tracks to be connected);
- a good mechanical connection between the networks to be connected;
- a regular spacing between both networks forming the cell;
- easy and general implementation (screen printing);
- lack of specific surface treatment in order:
 - to prevent abrasion on the thin layers;
 - to prevent oxidation of the zones in contact;
 - to facilitate the welding.

The device of the invention provides a permanent connection between a liquid crystal flat screen and its printed control circuit, and the transfer, onto just one of the two substrates forming the matrix screen, of all the conducting tracks so as to provide the connection to the control electronics on one and the same face of the plane.

This device produces an interconnection having low electrical resistance of networks of conducting rows with a fine pitch from one plane to another plane.

The subject of the invention is a connection device for a display screen reproducing analysed images in the form of a grid of rows and columns, this screen comprising a layer of a material, which is recordable by a mixed thermal and electric effect, included between two transparent plates in which the webs of transparent and parallel electrodes are placed on these two plates, this connection device being characterized in that it comprises conducting microballs, insulating microballs of a size

less than that of the conducting microballs, and playing the role of spacers between the two glass plates, in suspension in a polymerizable resin; these conducting microballs having a mechanical strength allowing creep when crushing the layer of recordable material between the two plates in order to achieve the connection, the insulating microballs having a higher crush strength than that of the conducting microballs.

The invention will be better understood and other advantages will become apparent with the help of the following description, with reference to the appended figures.

- Figure 1 shows a connection device of the prior art;
- Figure 2 shows the connection zones of a device of the prior art;
- Figure 3 shows the connection zones of the device of the invention;
- Figure 4 illustrates a matrix flat screen with smectic liquid crystal;
- Figure 5 illustrates a diagram of the control for a network as illustrated in Figure 4;
- Figure 6 illustrates a section of the device of the invention along the axis of the conducting rows;
- Figure 7 illustrates a section of the device of the invention in a direction perpendicular to the axis of the conducting rows;
- Figures 8 to 10 illustrate a display screen comprising the device of the invention.

Of the possible various display devices, the invention is most particularly applicable to the high-definition liquid crystal display screens of the matrix type.

The invention is in particular applicable to display screens comprising liquid crystals in the smectic phase, which are current controlled.

It is known that when cooling a thin layer of a material having a smectic phase starting from the liquid phase, the optical appearance of the thin layer depends heavily on the cooling rate. If the cooling takes place in an electric field, the material orients itself uniformly and the layer appears to be perfectly transparent. If on the other hand, the transition from the liquid phase to the smectic phase takes place naturally in the absence of an electric field, domains having different orientations with respect to each other are formed in the layer leading to high scattering of the transmitted or reflected light. This effect can be used to record an image on a film of liquid crystal having a smectic phase. The material, placed between two transparent plates, is kept at a temperature such that it is in its smectic phase, an image point is recorded by heating the liquid layer followed by applying the electric field. The amount of heat needed to melt the liquid crystal layer can be provided by infrared radiation or by laser radiation. However, it is possible to increase the rate at which the image is recorded in a layer of material having such a thermoelectric effect by using components which are heating resistors making it possible to record an image row by row, which then makes use of the duration of a row in order to simultaneously record all the points of this row. This recording and erasure method is faster than the optical methods and makes it possible to come close to recording video images on a display screen.

Figure 1 shows a connection device for conductors arranged over two elements, according to the prior art. It has been chosen to represent the connection system of a glass substrate 1 which may be one of the plates supporting one of the electrode networks of a display screen with matrix access. The element 10 symbolizes the rest of the display screen comprising, for example a liquid crystal layer inserted between the plate 1 and another plate 11 supporting the other electrode network of the

screen. Conductors 2 are etched on the substrate 1 on the same side as the element 10. They are arranged mutually parallel and are regularly spaced. For a light ray incident on the substrate 1 to be able to access the liquid crystal layer of the screen, it is necessary for the conductors 2 to be transparent. They may consist of an indium oxide layer. A printed circuit 3 is placed under the element 10 and supports elements 4 forming part of the electronic circuits controlling the screen. It is understood that the electrical contacts between the inner face of the printed circuit 3 and the conductors supported by the plate 11 are easy to produce. On the other hand, the connections between the conductors 2 of the substrate 1 and the corresponding conductors 5 on the printed circuit must be provided by means of a connector 6. The ends of the conductors 5 are etched with the same pitch as the conductors 2 and are located facing these conductors. The connector 6 generally consists of an elastomer body 7 which is circled around its largest dimension with mutually insulated conducting tracks 8 parallel to the conductors 2 and 5. The space separating the tracks 8 from each other is of the same order of magnitude as the width of these tracks. The pitch of the connection tracks is generally chosen to be less than that of the conductors to be connected. This has several advantages: the positioning of the connector with respect to the conductors to be connected does not need to be strict and the risks of short circuits between conductors are thus avoided. A second connector 9 playing the same role as the connector 6 may be provided at the other end of the conductors 2. Slight clamping exerted on the assembly, as indicated by the arrows, provides the electrical contact of the various parts. Since the bodies of the connectors are made of elastomer, they deform slightly under the effect of clamping ensuring an efficient contact. However, it is essential to align the conductors of the substrate with those of the

printed circuit. This operation is quite delicate, particularly if the substrate is not transparent and consequently does not allow visual alignment.

Figure 2 shows schematically the connection zones of a device of the prior art.

Figure 3 shows schematically the connection zones of the device of the invention.

The device of the invention makes it possible to ensure the transfer, onto just one of the two substrates forming the matrix screen, of the set of conducting tracks so as to combine the connection with the control electronics on the same face of the plane.

In these two figures, the arrows indicate the connection zones of the electrodes deposited on the two transparent plates 12 and 13 clamping the liquid crystal layer of a display screen with matrix access, and their orientation relative to the technology of matrix flat screens with smectic liquid crystals on which the display of information is obtained by a thermooptic effect which makes it possible to switch from an isotropic state of the crystal, when the latter is heated, to a scattering state if the crystal is cooled spontaneously, or to a transparent state if this cooling takes place in an electric field.

Figure 4 shows a matrix flat screen with a smectic liquid crystal.

The two layers 20 and 21 are, for example, made of glass, the network 22 is the one which makes it possible to apply the electric field E . The network 23 supplies the heating power. The zone 24 represents the space filled by the liquid crystal.

To produce a connection ensuring the transfer of the heating power, it is possible to consider the diagram of the heating control shown in Figure 5.

Specifically, it is necessary to take into account requirements associated:

- with the technologies of the control circuits (maximum output voltage and

maximum power that can be output: $P_M = U^2/R$ (R being the output resistance of the circuits);

- with the technology for producing the heating network $R = \rho \frac{l}{e\epsilon}$

ρ is the resistivity of the material forming the heating electrode,

l is the length of the heating electrode,

e is the width of the heating electrode,

ϵ is the thickness of the heating electrode.

Also, it is essential to produce connections introducing spurious series resistances which are as small as possible. ($r = R/10$ being a minimum).

Spurious resistances are considered, whose values do not exceed a fraction of an ohm. Mismatching of the impedances is thus minimal and the power lost at the connection level is negligible.

In Figure 5, the control circuit support 26, the connections 27 and the liquid crystal cell 28 are shown.

The heating power is $P = Ri^2$ where $R = 15$ to $30 r$ for example

$$i = \frac{U}{\sum R_i}$$

by construction $R_3, R'_3 \ll R$

$$R, R'_1 \ll 0.1 \Omega$$

with $i = 1$ to 2 amperes (pulses)

and $R_2 + R'_2 < 1 \Omega$

where R_2, R'_2 are the spurious connection resistances.

In such a cell, the electrode networks face each other in the cell, which, in

order to produce the supports for the control circuits, leads to:

- either the use of two support families;
- or a reversal operation dependent on flexible circuits.

The device of the invention makes it possible to carry out this transfer during the operation of sealing the cell.

Depending on the type of layers used to produce the networks, the video network (semitransparent indium-tin oxide (ITO)) can be transferred to the plane of the heating network (aluminium) or the heating network (aluminium) can be transferred to the plane of the video network (copper indium-tin oxide (ITO)). In this case also, the essential condition is that the perturbing resistance is very much less than the resistance of the heating row.

In the device of the invention, the low-resistance electrical contact is provided only by deformation of metal elements, in contact with the tracks. The insulation and the mechanical durability are provided by an adhesive or a polymerizable resin which may seal the contact zones. The role of spacers is taken by the insulating balls (glass balls) whose crush strength is much greater than that of the metal elements. These balls limit the possibility of short circuits in the event of too much crushing.

The various elements of the device of the invention are shown in Figures 6 and 7 which are sectional views of the device of the invention along the axis of the conducting rows and along a direction perpendicular to this axis, respectively.

- The conducting elements 35 are conducting metal microparticles or microballs of graded dimensions. The amount and the dimensions thereof are associated with the type of connection system to be produced (pitch of tracks, width of insulators, distance between the networks to be connected and implemented).

- The spacers 37 are microparticles or microballs made of glass (or another hard and electrically insulating material) of graded size. The number and the dimensions of the latter must comply with the same criteria as the conducting elements. However, their dimensions are less than those of the metal elements.

- The adhesive or resin 36 are used together, and they include the conducting elements and the spacers in suspension. This resin must be: compatible with the suspended materials; compatible with the metals forming the tracks; adhere to and be compatible with the substrates bearing the tracks. It may be polymerized in-situ by any of the conventional methods.

The device of the invention therefore comprises:

- the substrate 31 whose row network it is desired to transfer
- the transfer substrate 32
- the conducting row 33 to be transferred
- the transfer conductor 34
- the conducting metal microballs 35
- the linking resin 36
- the insulating microballs 37.

These conducting metal elements may be: made of soft metals or alloys which have a low crush strength such as aluminium, indium, copper and their alloys, for example. These metal elements have the following properties: low electrical resistivities; average mechanical crush strength in order to be able to creep suitably while being crushed in position; the sizes may range between 5 and 25 μm . Depending on the application, a slice of, for example, 5 μm in width is selected, which above all depends on the spacer between the networks (for example 15 to 20 μm for a 10-15 μm

spacer) which have a low crush strength.

The quantity suspended is determined as a function of the volume, from the dimensions of the zones to be connected, the desired number of contact points and the width of the insulating zones over each network. For a quantity greater than a maximum, the phenomenon known as percolation (agglomerate) of the particles is obtained which leads to short circuits between contiguous tracks. With regard to the shape of the particles, it is desirable that the form factor (that is to say the ratio

$$\frac{\text{largest dimension}}{\text{smallest dimension}}$$
 for the same particle) does not exceed 1.5 to 2.

The spacers may be insulating microballs made of glass or any other hard insulating material. The said "microballs" may be replaced by segments of fibres (for example made of glass). They have the following properties: good electrical insulation; high crush strength; dimensional uniformity. This favours the glass fibres over the microballs; the quantity suspended depends on the importance of the spacing problem and makes it possible to control the viscosity of the adhesive of the resin by adapting it to the implementation method.

With regard to the adhesive or resin, apart from the problem of compatibility with the materials in use, it is necessary to use a rapidly polymerizable material in order to obtain a permanent connection. The polymerization technique may be as follows: ultraviolet radiation + pressure; or the pair temperature-(application time) + pressure which may be critical only if the temperature-time pair is high and not dampened before any disturbance of the liquid crystal when the latter is in the cell.

Figures 8, 9, 10 illustrate a display screen comprising the device of the invention; Figures 9 and 10 being two sectional views, Figure 9 along the sectional

plane BB' and Figure 10 along the sectional plane AA'.

As shown in Figures 6 and 7, the two transparent plates 31 and 32 comprise, on their mutually facing faces, webs of transparent and mutually parallel electrodes which make it possible to address all points of the liquid crystal which is located between these two plates 31 and 32.

A bead of resin is placed between these two plates along the entire surface of the plate 31. The electrode web 45 is placed over the entire length of the plate 32. On the other hand, the electrode web 44 and the electrode web 43 are not connected to each other. They are connected via the resin 36 and the electrode web 46 deposited on the plate 31; the zone 47 being that of the active substance which may comprise, for example, liquid crystals.

By way of non-limiting example, the following values can be considered:

- electrode webs with a pitch of 700 μm , the width of the electrodes being about 350 μm ;
- each of the two networks having 100 tracks, one network being an aluminium coating on a glass support, and the other a copper coating on a flexible support;
- the conducting microballs forming 7 to 10% of the resin volume;
- 15 to 35 μm copper-lead conducting microballs having a form factor of 1.5;
- 17 to 20 μm insulating microballs forming 5% of the resin volume;
- the resin being the polymerizable araldite while using the temperature-time pair, the adhesive bead deposited having a width of about 1 mm.

The device which is the subject of the invention provides:

- a spurious electrical resistance between the networks to be connected of less

than one ohm;

- a very high insulating electrical resistance between contiguous tracks of the same network;

- good sealing of the contact points;

- significant connection redundancy (several tens of contact points between the tracks to be connected);

- a good mechanical link between the networks to be connected;

- a regular spacing between the two networks forming the cell;

- easy and general implementation (screen printing);

- lack of specific surface treatment in order to:

- prevent abrasion on the thin layers;

- prevent oxidation of the zones in contact;

- facilitate the welding.

Thus the device of the invention is applicable to:

- a bead for sealing liquid crystal flat screens with matrix access;

- a low resistance (less than one ohm) connection for flat screens;

- all connections of low thickness and large size made between a high number of points in a plane.

CLAIMS

1. Connection device for a display screen reproducing analysed images in the form of a grid of rows and columns, this screen comprising a layer of a material, which is recordable by a mixed thermal and electric effect, included between two transparent plates (31, 32) in which the webs of transparent and parallel electrodes are placed on these two plates (31, 32), this connection device being characterized in that it comprises conducting microballs (35), insulating microballs (37) of a size less than that of the conducting microballs, and playing the role of spacers between the two glass plates (31, 32), in suspension in a polymerizable resin (36); these conducting microballs (35) having a mechanical strength allowing creep when crushing the layer of recordable material between the two plates in order to achieve the connection, the insulating microballs (37) having a higher crush strength than that of the conducting microballs (35).

2. Device according to Claim 1, characterized in that the conducting microballs (35) have a diameter within the range 5 to 50 micrometres.

3. Device according to Claim 1, characterized in that the conducting microballs (35) are made of metal.

4. Device according to Claim 3, characterized in that the conducting microballs (35) are made of copper, aluminium or indium.

5. Device according to Claim 1, characterized in that the conducting microballs (35) are made of an alloy.

6. Device according to Claim 5, characterized in that the conducting microballs (35) are made from an aluminium, indium or copper alloy.

7. Device according to Claim 1, characterized in that the insulating microballs

(37) are made of glass.

8. Device according to Claim 1, characterized in that the insulating microballs (37) are segments of glass fibres.

9. Device according to Claim 1, characterized in that the conducting microballs (35) have a form factor less than 2.

10. Display screen comprising the device of Claim 1, characterized in that the recordable material is of the liquid-crystal type in the smectic phase

ABSTRACT

The invention relates to flat-type display screens comprising two transparent plates, more particularly those with smectic liquid crystals. It allows remote connection of such a flat screen. It comprises conducting microballs 35 and insulating microballs 37 in suspension in a polymerizable resin 36 placed between the two plates 31, 32.

Application to the display of images for television and display peripherals, for remote transmission.